

# Lag time in water quality response to land treatment



Donald W. Meals  
Steven A. Dressing



Some watershed land treatment projects have reported little or no improvement in water quality after extensive implementation of best management practices (BMPs) in the watershed:

- insufficient landowner participation
- uncooperative weather
- improper selection of BMPs
- mistakes in understanding of pollution sources
- poor experimental design
- inadequate level of treatment

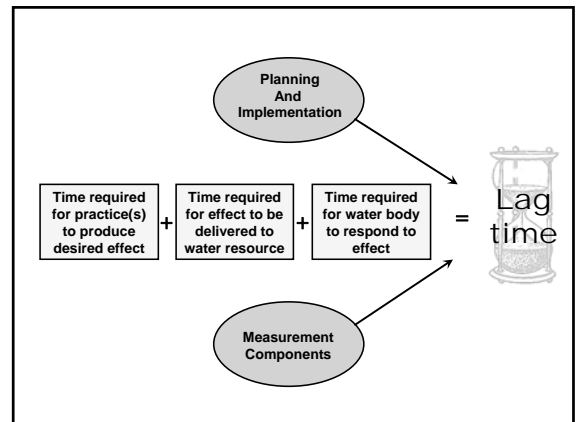
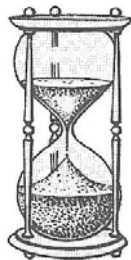
## Lag time

An inherent characteristic of natural systems generally defined as the amount of time between an action and the response to that action

Lag time is the time elapsed between installation or adoption of land treatment and measurable improvement of water quality.

If lag time > monitoring period....

May not show definitive water quality results



## Planning & Implementation

- identify pollution sources and critical areas
- engage landowner participation
- design and install management measures
- integrate new practices into cropping and land management cycles.

Stakeholders – especially the general public – will experience the planning and implementation process as part of the wait for results.



## Time Required for Practice to Produce Effect

### BMP Development



## Time Required for Practice to Produce Effect

### BMP Development



• [TP]	-15%
• [TKN]	-12%
• [TSS]	-34%
• <i>E. coli</i>	-29%

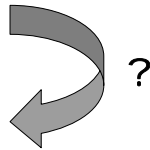
## Time Required for Practice to Produce Effect

### BMP Development



## Time Required for Practice to Produce Effect

### BMP Development



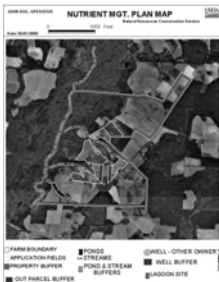
## Time Required for Practice to Produce Effect

### Source Behavior



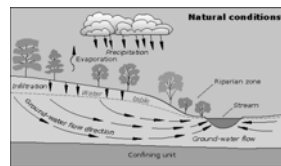
## Time Required for Practice to Produce Effect

### Source Behavior



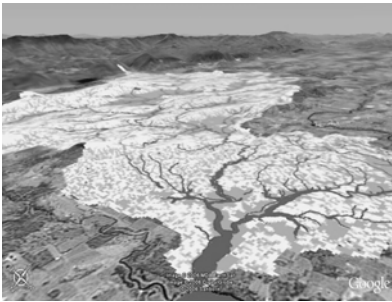
## Time Required for Effect to be Delivered

- **Delivery route**
  - Direct or adjacent
  - Overland flow
  - Ground water



### Time Required for Effect to be Delivered

- **Path distance**



### Time Required for Effect to be Delivered

- **Path travel rate**

- Fast (ditches, tile outlets)
- Moderate (overland./subsurface flow in porous soils)
- Slow (groundwater infiltration w/o macropores)
- Very slow (regional aquifer)



### Time Required for Effect to be Delivered

- **Precipitation patterns**



### Time Required for Effect to be Delivered

- **Nature of pollutant**

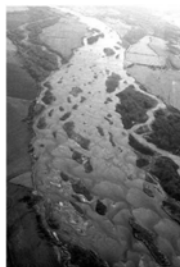
Dissolved



### Time Required for Effect to be Delivered

- **Nature of pollutant**

Particulate



### Time Required for Water Body to Respond

- **Nature of indicator/impairment**

- **Indicator bacteria**

- Die-off from environmental stresses
- Even with survival in aquatic sediments, stock eventually depleted



- **Synthetic organics**

- Persistence
- Bioaccumulation



## Time Required for Water Body to Respond

### • Nature of indicator/impairment

Habitat



## Time Required for Water Body to Respond

### • Nature of indicator/impairment

Habitat



Biota



## Time Required for Water Body to Respond

### • Receiving water response

Bacteria from animal waste

↓ ↑  
Shellfish beds



## Time Required for Water Body to Respond

### • Receiving water response

Transparency?  
Algae blooms?



P in aquatic sediments



## Measurement Components

Design of the monitoring program is a major determinant of ability to discern a response against the background of the variability of natural systems

### Sampling frequency

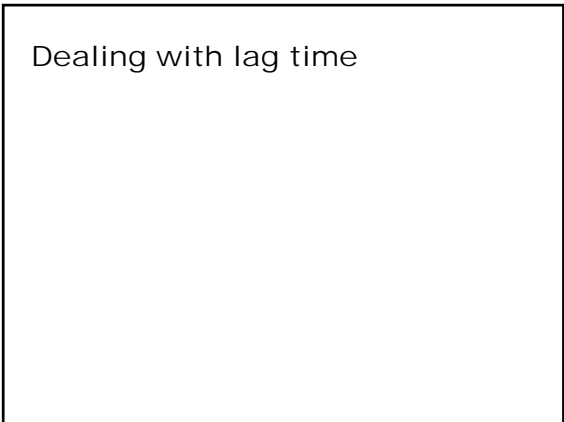
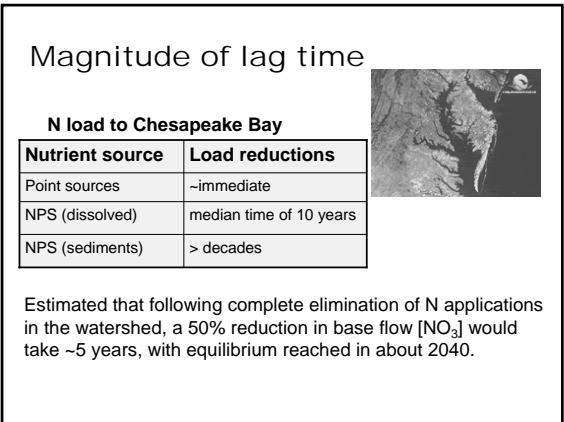
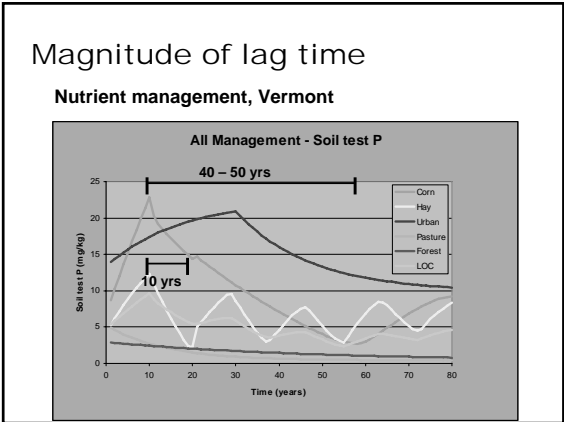
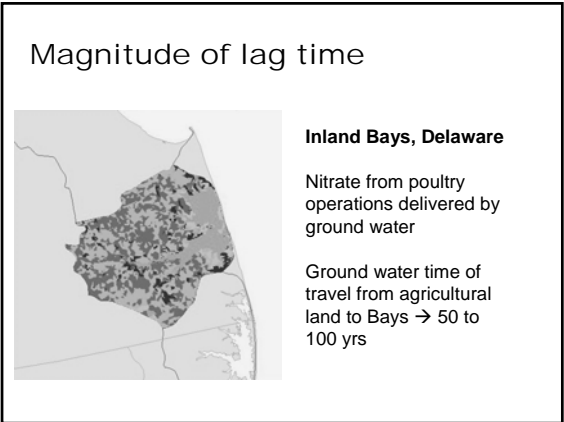
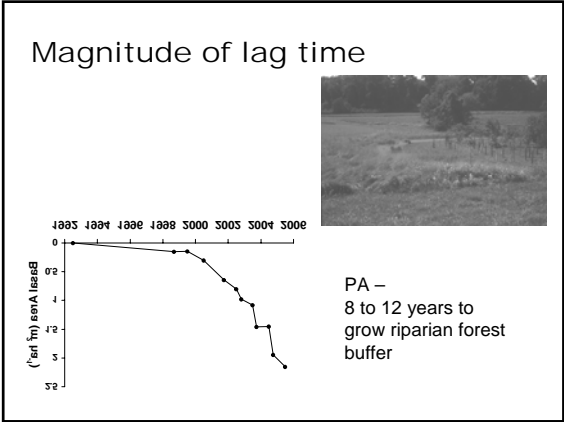
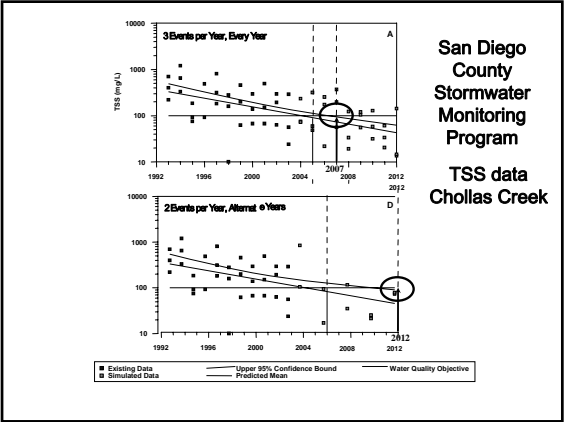
Taking fewer samples a year introduces an additional "statistical" lag time before a change can be effectively documented.

**Minimum detectable change** = how much change must occur (e.g., from implementation of conservation practices) for the change to be statistically significant.

The minimum detectable change (MDC) is given by

$$MDC = T_{(n_{pre} + n_{post} - k - 2)} \sqrt{\frac{MSE_{pre}}{n_{pre}} + \frac{MSE_{post}}{n_{post}}} \quad (1a)$$

Richards and Grabow, 2003. Detecting Reductions in Sediment Loads Associated With Ohio's Conservation Reserve Enhancement Program. J. American Water Resour. Assoc. 39(5):1261-1268.



## Dealing with lag time

### Recognize lag time and adjust expectations



## Dealing with lag time

### Characterize the watershed

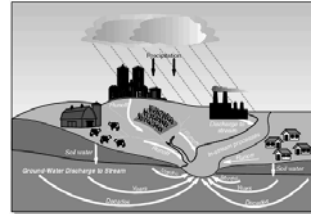


Figure 2. Sources movement in the ground-water flow system.

## Dealing with lag time

### Consider lag time in selection of BMPs



## Dealing with lag time

### Consider lag time in siting of BMPs



Treat sources likely to exhibit short lag times first to increase the probability of demonstrating WQ improvement as quickly as possible. **BUT** → "Quick-fix" practices with minimum lag time should not automatically replace practices implemented in locations that can ultimately yield permanent reductions

## Dealing with lag time

### Monitor small watersheds close to sources



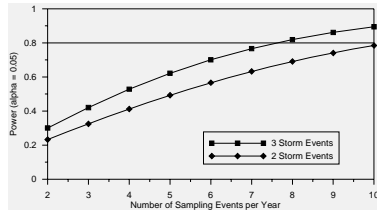
## Dealing with lag time

### Select indicators carefully



## Dealing with lag time

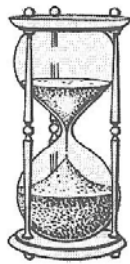
Design monitoring programs to detect change effectively



## Dealing with lag time

Use social indicators  
as intermediate check  
on progress →

Are things moving in  
the right direction?



QUESTIONS?